Proceedings of the 33rd European Safety and Reliability Conference (ESREL 2023)
Edited by Mário P. Brito, Terje Aven, Piero Baraldi, Marko Čepin and Enrico Zio
 Published by Research Publishing, Singapore.
doi: 10.3850/978-981-18-8071-1_P382-cd

Applying Functional Resonance Analysis Method to strengthen resilience in the Norwegian customs infrastructure

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Accelerated globalization, climate change, and armed conflicts generate emerging security challenges at borders for the Norwegian custom administration (CA) authorities. CA has a critical role in governing management efforts to mitigate threats related to their social mission. Nevertheless, besides daily operational challenges, dealing with some events may go beyond the standard procedures and propagates over multiple interconnected functions delivered by other governmental agencies such as police- and health department. Managing such complexities in a CA's operational context requires a holistic management system capable of addressing uncertainties and interconnectivity between involved agencies. In this regard, resilience-based thinking, and its design in the system under study has been acknowledged to be promising for dealing with dynamicity and managing risk proactively. This study applies concepts and approaches from the resilience engineering field and explores the Norwegian Customs' ability to co-locate and coordinate with other government responding agencies at the border. We examine the interoperability between involved agencies in joint operations through the lens of the Functional Resonance Analysis Method (FRAM). Our findings support the advantages of FRAM in studying a system's attributes. We conclude by outlining recommendations for strengthening resilience in the Norwegian customs border facilities such as a holistic approach to risk management, emergency planning and training for cooperation and co-location and proposing further research endeavors.

Keywords: FRAM, Complex Systems, Resilience, border facilities, interoperability, co-location, interagency, cooperation.

1. Introduction

The complexities and challenges of managing cross-border movements of goods are ever-evolving (Adrot et al. 2018), making the social mission of the Norwegian Customs Administration (NCA) increasingly challenging. NCA's vital role is to ensure compliance with laws and regulations for such movements, which requires significant coordination and cooperation with various actors, e.g., the police department and the Norwegian Directorate of Health. However, this mission is not without its difficulties, particularly considering unexpected events that can strain the capacity for collaboration and co-location at border facilities. To enhance this capacity during anticipated and unforeseen circumstances, the NCA recognizes the need to strengthen its border facilities ("Norwegian Customs Strategy - Norwegian Customs" n.d.) As part of its strategy, NCA is collaborating with the Norwegian government's building commissioner (Statsbygg) to develop a "standardized border facility" comprising modular units with flexible design, size, and local adaptations to cater to the agency's current and future operational requirements. Nevertheless, the success of this initiative hinges on daily collaboration among stakeholders, particularly in responding to unforeseen events Steen, et al., 2022) (Bellini, Nesi, and Ferreira 2016). Furthermore, the lessons learned from the COVID-19 pandemic (Golunov and Smirnova 2022) present an opportunity to improve emergency planning and border facility design, fostering interdisciplinary cooperation during co-location requirements.

This study focuses on the NCA's border operations and aims to answer the following research question: how Resilience Engineering (RE) concepts and methods can be applied to enhance interdisciplinary collaboration and co-location at standardized border facilities for cross-border movements of goods. Specifically, the study aims to explore the potential benefits and challenges associated with this approach, and to identify strategies for overcoming any obstacles that may arise. To address this research question, the study applies the Functional Resonance Analysis Method (FRAM) (Cantelmi et al. 2022; Hollnagel 2012; Steen, Patriarca, and Di Gravio 2021) to analyze the interdependencies and variations between activities during daily operations at standardized border facilities. Furthermore, FRAM is used to identify the potential needs of various actors involved in responding to emergencies in these facilities. The ultimate goal is to better understand how the RE approach can be leveraged to improve the effectiveness of collaboration and co-location in such settings.

2. Theoretical background

2.1 *Resilience and resilience engineering*

Woods (2015) provides a broad typology of the resilience concept, dividing it into four categories: (1) as a rebound from challenging circumstances; (2) as a synonym for robustness; (3) as the opposite of brittleness, that is, graceful extensibility when surprise confronts boundaries; and (4) as network architectures that can sustain the ability to adapt to future surprises while conditions evolve. In broad terms, these categories point to resilience as the capacity of a system to adapt to adversities while sustaining operations (Bruneau et al. 2003; Provan et al. 2020). In this paper we consider resilience as the capacity of a system to sustain operations while adapting to adversities. By adopting an anticipatory approach that involves proactively identifying and addressing potential challenges, organizations can enhance their resilience and effectively adapt to changes in their environment (Bergström, van Winsen, and Henriqson 2015). Resilience capacities are related to the three main areas of concern:

- Adaptation that reflects learning, flexibility to experiment, the adoption of novel solutions and the development of responses that may also divert from the planning (Walker et al. 2002).
- Redundancy, which refers to the availability of substitutable elements or systems that can be activated when disruptions occur (Bruneau et al. 2003).
- Resourcefulness, refers to the capacity to mobilize and apply material and human resources to achieve goals in the event of disruptions (Bruneau et al. 2003).

Moreover, training activities, procedures, structures, and plans are elements that reinforce capacities. Vital in this respect is the system's capability to anticipate, respond, synchronize, and learn proactively (Provan et al. 2020):

- Anticipation is about creating foresight on future operating conditions and revising risk models. Anticipating future scenarios allows the organization to monitor the conditions and threats associated with these scenarios, as well as to build resources and capacities to respond.
- Readiness to respond concentrates on the maintaining deployable reserve resources to be available to keep pace with demand. Deployment entails that employees have sufficient autonomy to make decisions about their work in real-time. This requires that employees have the psychological safety to apply their judgement without fear of repercussion.
- Synchronization focuses on coordinate information flows and actions across the networked system. This synchronization provides a constant opportunity to understand the changing shape of the system, the extent to which operations remain within safe operating boundaries.

- Proactive learning is about seeking context and understanding what is needed to support safe adaptation and success on the front line. It emphasizes on a search for brittleness, gaps in understanding underlying elements trade-offs, and reprioritisations.

To enhance resilience, Hollnagel (2017) emphasises that organizations should embrace and monitor the adaptive cycles of work, fostering proactive learning. Anticipation is about creating foresight on future operating conditions and revising risk models. Anticipating future scenarios allows the organization to monitor the conditions and threats associated with these scenarios, as well as to build resources and capacities to respond. Results from anticipation process provides insight for crisis preparation (Boin and van Eeten 2013). An emergency plan is usually developed containing information about the nature of the risks and threats, the likelihood of risks, who/what is exposed to the risks, and different scenarios. In addition, the emergency plan contains practices and procedures in terms of a division of responsibilities and roles for the involved actors (Lunde and Njå 2021).

2.2 *Functional resonance analysis method*

The Functional resonance analysis method (FRAM) is based on a systemic perspective that views an organization as a complex socio-cultural system. As a tool, it is developed to analyze complex systems by examining how they respond to unexpected events, and how the interactions between different components of the system contribute to its resilience or vulnerability (Hollnagel 2012; Patriarca et al. 2018). The effectiveness of a system is determined by the dynamic interplay of different functions throughout the system, and FRAM captures these functions through the identification of six aspects: Input (I), Output (O), Preconditions (P), Resources (R), Time (T), and Control (C). These aspects are represented by hexagons connected to each other, indicating the potential couplings between functions. It is important to note that these couplings may or may not become active or operational, and different functional scenarios can be simulated through the FRAM model, known as instantiations. In the context of resilience engineering, FRAM is often used as a tool for identifying potential vulnerabilities and assessing the ability of a system to cope with unexpected disruptions. The term "function" employs in FRAM to refer to the activities or tasks that are necessary to achieve a goal or what an organization does (Hollnagel 2017). In the context of risk management, different functions encompass various operational, technical, and organizational activities such as risk identification, vulnerability analysis, risk evaluation, risk treatment, and control (Steen and Ferreira 2020).

FRAM is a widely utilized approach for exploring operational context, conducting risk assessments, and analyzing accidents in socio-technical systems. For instance, it has been applied to explore the operations of the Brazilian Environmental Defense Centers (EDC), which provide response services following oil spill accidents (Cabrera Aguilera et al. 2016). Application of FRAM provided useful insights for identifying various constraints and conflicting procedural practices within the EDCs that affect the quality of their emergency management. The application of FRAM has helped to highlight functional variability in planning, preparedness, execution, resources, and human factors that contribute to these constraints (Alm and Woltjer 2010).

3. Research Methodology

The present study aimed to investigate the potential for enhancing the resilience of the NCA at border facilities. To accomplish this, we focused on identifying the interconnections that are crucial for effective collaboration and co-location at such facilities, using FRAM. However, to simplify the analysis and maintain the scope of the study, a reconstructed version of the FRAM model is included in this study. We conducted five semistructured interviews with central actors in custom border collaboration. They include representatives from the NCA, health department directorate, police department, the Norwegian Environment Agency, and the Norwegian food safety authority.

Prior to the interviews, we prepared an information letter to explain the aim of the study. We also informed the informants about our commitment to ethical practices, e.g., protecting their identity throughout this research, particularly regarding anonymity. An interview guide was developed on the theoretical basis of FRAM. To comprehensively capture critical aspects of collaborative processes during unexpected events, we asked informants to develop a scenario related to site localization and infrastructure prior to the interviews. The interviews were conducted on Teams for geographical reasons. Notes taken during the interviews were transcribed and categorized, and follow-up questions were sent to the informants. We used coding to analyze our data (Elliott 2018), breaking down transcriptions into smaller parts and assigning labels to them based on patterns and concepts identified in reflection memos. Our initial codes included operational environment, uncertainty, time pressure, communication, expectation, tacit knowledge, resources, training activities, etc. These codes were then iteratively refined and categorized using FRAM terminology.

4. Discussion

Our data indicate that the main challenge faced by border facilities is the ability to respond effectively to unforeseen events in a timely manner, while also ensuring collaboration among relevant actors. To effectively address this challenge, it is crucial to gain a thorough understanding of the context in which joint operations take place, Fig. 1 shows FRAM instantiation for establishing co-location context, involved at boarder facilities.

During the interviews, it became clear that a comprehensive risk assessment is necessary to facilitate co-location and effective collaboration at a border facility. Such an assessment can aid in the planning and management of cooperation among the various actors involved (Bynander and Nohrstedt 2019). Notably, our findings reveal that, as of the writing of this article, there is a lack of risk assessment for collaboration in diverse contexts beyond cross-border contagious diseases (NOU 2022: 5 p. 449). The importance of contextualizing risk assessment from the perspective of the different actors to demonstrate how they impact each other during an emergency is underscored by NOU (2022, 449).

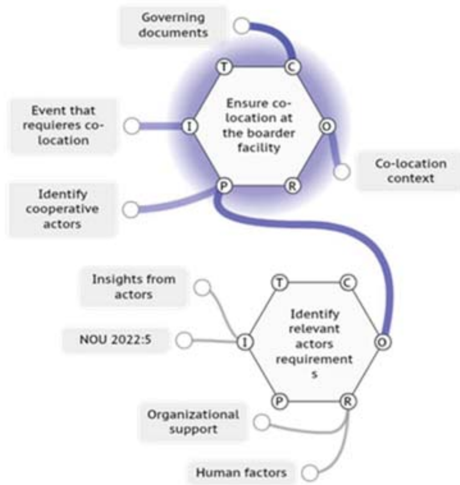

Fig. 1. FRAM instantiation of establishing context

One informant reflects on this need as follows:

"[…] there is a need for better coordination between relevant actors, addressing the various dimensions of the problems, role conflicts and area of responsibilities […]."

This statement implies the need to prepare a risk assessment to manage risks associated with co-location and collaboration in border facilities.

4.1 *Establishing a cooperation environment*

The process of establishing a resilient cooperation environment requires significant resource allocation, as well as building trust through diverse cross-sector collaborations and partnerships in advance of emergency situations (Pollock et al. 2019). Fig. 2 illustrates the critical elements necessary for establishing a cooperation environment in NCA border facilities.

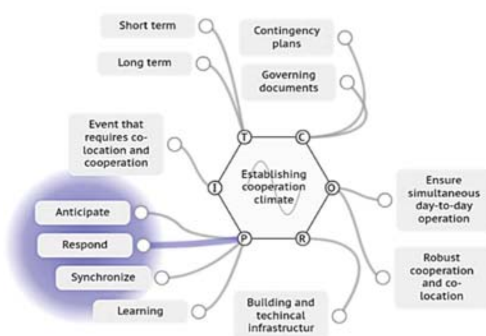

Fig. 2. FRAM instantiation of key factors for resilience

The crucial factors, highlighted as the precondition in Fig. 2, include the NCA's capability to anticipate, respond, synchronize, and learn proactively (see Section 2.1). Focusing on efficiency targets and maximizing resource utilization can lead to insufficient resources, preventing the organization from achieving resilience and responding to unforeseen events while also meeting day-to-day operational demands (Provan et al. 2020, 6). Our research findings indicate that responsibility and authority are not clearly defined. While our findings indicate a lack of skilled resources, and potential delays in resource allocation during the initial phase of an emergency. According to our informant: *[...] It is somewhat unclear who's responsible for the emergency response, whether it is the professional authority or the police, who are seen as the operational body.*

One challenge that was mentioned is what happens if the police are not present: *[...] who then becomes responsible for the emergency response?*

Figure 3 illustrates the essential factors that must be in place to enable a proactive and effective emergency response.

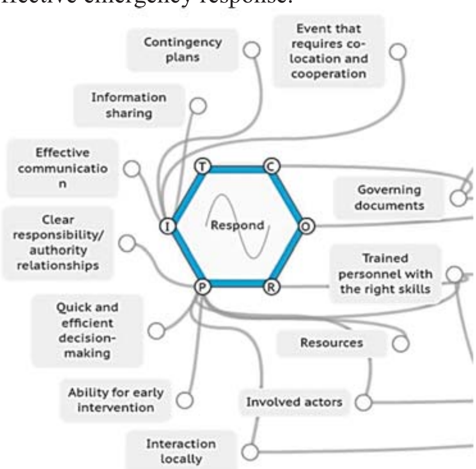

Fig. 3. FRAM instantiation of respond

According to an informant, a common problem with having sufficient resources is that when complex, unforeseen events occur simultaneously with daily operations, the organization is unable to handle them without additional skilled resources. The informant stated: *"[...] we are not resourced to manage larger incidents over time while also carrying out our daily operations without bringing in additional skilled resources..."*.

The lack of training and preparedness among actors for cooperation and co-location scenarios at border facilities hampers the readiness to respond (see Section 2.1) and exacerbates the problem. Challenges are often resolved via informal channels and acquaintances established through day-to-day operations. While this suggests that the actors have adaptability and can adjust to find solutions for various situations requiring co-location and cooperation, it may take time and may interfere with other tasks if the incident requires follow-up over an extended period (Pollock et al. 2019). The COVID-19 pandemic highlighted significant challenges in Norway's well-structured emergency response system, exposing a lack of integration between individual risk assessments of actors and their interrelationships (NOU 2022: 5, p. 449). Therefore, it is recommended that the authorities develop contingency plans to contain the transmission of imported infectious diseases at the border (NOU 2022: 5, p. 244).

The interviews revealed that the actors often find solutions over time by requesting assistance from the Armed Forces and allocating additional resources. One of our informants explained that planning for resources or requesting additional support is essential: *"We must plan for resources or request additional in accordance with the instructions for Armed Forces support to the Police Department [...]".*

This statement highlights the need for adequate planning and preparedness to avoid delays and mitigate the impact of emergencies (Christensen, Lægreid, and Rykkja 2015). The effectiveness of the actors' ability to find solutions in co-location and cooperation scenarios depends on the situation and location and may be hampered by the lack of clear time requirements and joint practice. Furthermore, the interviews suggest that much of the dialogue occurs informally, through acquaintances and pre-existing relationships between individuals, rather than through formal agency channels. Although this highlights the actors' adaptability and capacity to find solutions (Steen, Haakonsen, and Steiro 2023) it also implies that addressing challenges may take time and could divert attention from other tasks if follow-up is required over an extended period.

Based on the findings, it is suggested that the actors collaborate on a joint risk assessment, preparedness analysis, and preparedness plan. This should include local adaptations to ensure the appropriate allocation of necessary resources, and that the actors have the required competencies to assist each other and work together without interfering with day-to-day operations. The lack of clarity on which actor should take the lead in coordinating co-location may be addressed by adhering to the cooperation principle, whereby all actors have a responsibility to cooperate with each other.

The findings highlight the importance of reviewing and agreeing on emergency plans with relevant actors to enable an effective response to challenges during the initial phase. Without such plans, there may be variations in the precision of measures taken, which might decrease the ability to respond proactively and in a coordinated manner (Christensen, Lægreid, and Rykkja 2015). Cooperation and co-location involve complex technological, organizational, and human activities, which can be further challenged by the lack of preparedness among actors. To address this, the NCA could consider organizing a workshop with relevant actors to jointly develop a risk assessment and preparedness analysis for co-location. The workshop could include professionals from each individual actor to ensure a comprehensive understanding of the challenges and solutions. The outcome of the workshop could be incorporated into the emergency plans of individual actors and interconnected to establish a common understanding and ensure coordination.

4.2 *Assessing needs and priorities*

Emergency plans should provide a framework for prioritization based on the available capacity of each individual border facility. However, the lack of clarity around division of responsibilities and technical needs specific to each actor can lead to delays in decision-making and coordination in the initial phase (Steen and Ferreira 2020). Findings indicate that there have been inconsistencies in how incidents have been handled, which could have been addressed similarly regardless of location. To avoid these inconsistencies and ensure effective contingency planning for co-location, it is important for the border facility to conduct planning work that strengthens their ability to assess and prioritize locally, based on capacity. Capacity, rather than prioritization, may be the more critical factor in establishing effective cooperation in these circumstances.

According to the interviews, it seems that individuals can handle short-term events without significant difficulties. On the other hand, in case of long-term emergencies, adequate technical infrastructure is needed for office facilities. The specific size and requirements for such facilities are not clearly defined. The results show that little is known about how the increase in activity affects the increase in capacity of the facilities in the event of an incident, and what changes this may cause such as energy supply, ventilation, heating requirements, cleaning frequency, etc.

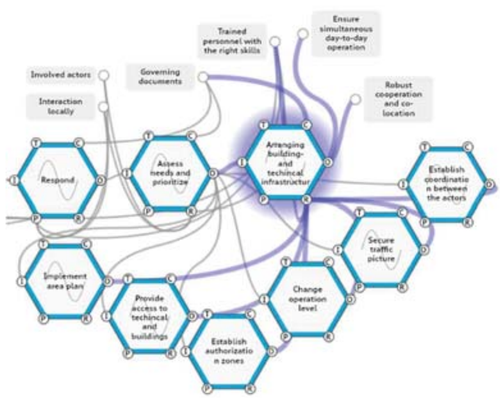

Fig. 4. FRAM instantiation of assessing needs and prioritizing

This finding may suggest that actors have limited expertise in the challenges that co-location at border facilities can cause and the resources required by it. Figure 4 shows the complexity of deliveries that an organization must handle with control and predictability in an emergency. In the event of irregular events, the function of facilitating technical infrastructure may be compromised due to lack of access to resources due to the lack of mapping of needs and requirements. Consequently, it is recommended to conduct joint risk assessments based on various emergency situations and to take measures to address needs and requirements in the event of an incident. This risk assessment can also reveal the limitations of the individual facility for an increased degree of operation and provide predictability of access capacity of border facilities. In addition, it is recommended to designate the residual capacity of the technical infrastructure of the individual border facilities that can be used in an incident and to conclude prioritised agreements with external providers for additional resources. In this way, it is possible to quickly establish the necessary capacities in the event of an emergency.

4.3 *Establish coordination between actors*

The interviews reveal that although there are general cooperation agreements between the NCA and cooperative actors and regular meetings, there are still gaps in information sharing during emergencies at the border facility. This lack indicates that there is no established protocol for how to work together. While information flows well internally and externally on a day-to-day basis, it becomes more challenging to share information with cooperative actors during an emergency. Furthermore, the time it takes to decide on co-location may vary among different border facilities due to differences in location and operational conditions. To enhance the resilience of joint emergency response operation, it is recommended that the NCA establish a clear protocol for information sharing during emergencies and develop contingency plans that include specific procedures for coordination and communication with cooperative actors. This will ensure that relevant information is shared promptly and that cooperative actors are involved in decision-making processes in a timely manner.

The effectiveness of the "Establish coordination between the actors" (Fig. 4) activity may vary depending on the level of training and expertise of the assigned resource. This activity involves coordinating various internal elements within the NCA's network to implement multiple activities. Therefore, the role holder must know when and how these activities should be initiated. In addition, clear communication with cooperative actors is crucial, ensuring that all actors are informed of the current status and guidelines for border facilities that have been established with co-location.

The role of the coordinator for establishing and operating a co-located border facility should be clearly defined in the emergency plan. The coordinator should participate in drills and training to become familiar with the role and develop effective decision-making skills in stressful situations that require immediate action. Additionally, the coordinator should actively participate in the development of plans that address all activities related to the "facilitating technical infrastructure" function to gain a thorough understanding of the prerequisites for a co-location context.

5. Conclusions and final remarks

In this study, we investigated how Resilience Engineering (RE) concepts and methods can be applied to enhance interdisciplinary collaboration and co-location at standardized border facilities for cross-border movements of goods. Our findings highlighted several functions for cooperation and co-location with links and dependencies, resulting in uncertainty and variation. Functional variation can have an impact on several activities required to establish RE. Using the Functional Resonance Analysis Method (FRAM), we explored the complexity of cooperation and identified the core elements for creating flow in activities. These included a risk assessment, preparedness analysis, and preparedness plan that should be agreed upon by all actors. However, our findings revealed that neither risk assessment nor planning exists for co-location at a border facility. To address this, we recommend that actors establish a workshop with central actors to develop joint risk assessment, preparedness analysis, and emergency plans, including local adaptation to ensure the right dimensioning of the necessary resources and competence, working together without disrupting daily operations. Additionally, we suggest establishing a coordinator role to facilitate effective communication and decision-making during emergencies.

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